

# Contagion: epidemiological models and financial crises

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## ABSTRACT

Since the 1990s, economists have drawn on the epidemiology of emerging infectious diseases to explain the diffusion of shock through an increasingly complex financial system. The successful coordination of public health responses to disease threats, and in particular the epidemiological modelling underpinning infection control, has influenced economists' understanding of the risks posed to the stability of the financial system by 'contagion'. While the exportation of analytic models and frames of reference can be fruitful, reinvigorating the destination domain, such analogizing can have a distorting effect. There are differences between biological and financial systems. Moreover, the migration of highly context-specific epidemiological models may undermine the basis of the analogy. Finally, there may be repercussions for the efficacy of public health in the way that its aims are misconstrued in financial analyses.

**Keywords** analogic models, networks, public health, risk

## Introduction

In March 2013, the identification of a novel strain of influenza A(H7N9) refocused the world's attention on the threat posed to human and animal life by emerging infections.<sup>1</sup> At the same time, Cyprus' downgrading to junk status, on the basis of its over-indebted banks, triggered volatility in the financial markets.<sup>2</sup> What do such apparently unrelated events—an infectious disease outbreak and a financial crisis—have in common? The aim in this essay is to consider the extent to which biological and financial systems may be comparable and to examine whether epidemiological models developed to explain the dynamics of infectious diseases may be usefully applied in a financial context to elucidate the nature of systemic risk.

Clearly, epidemics and financial crises share certain general features, such as the potential to spread globally in an increasingly interconnected world, characterized by rapid mobility of people, commodities, information and capital. Disease outbreaks may also induce market turbulence, necessitating catastrophic risk management. The relatively minimal economic impact of severe acute respiratory syndrome (SARS) on Asian economies in the Spring of 2003 underscored the extent to which economic risks are reduced where public health systems and governance structures are robust.<sup>3</sup> The

convergence of a global financial crisis (which subsequently turned into a sovereign debt crisis) with an influenza A(H1N1) pandemic in 2009 further drew attention to the economic consequences of public health responses and infection control.<sup>4</sup>

It is precisely in the context of risk mitigation that economists have appropriated epidemiology as an analytic instrument for understanding transmission and managing risk in a global financial system that is at once highly concentrated and interconnected. To adapt a term used by both disease ecologists and economists, today there is a discernible 'spillover' of epidemiological terminology into financial analysis. 'Contagion' has become common parlance in economics, raising critical issues about the feasibility of translating theoretical models from one domain to another.

This essay is organized in three sections: first, I consider financial 'contagion' theory within the context of a biological turn in economics from the 1990s, when a global financial crisis, originating in Southeast Asia, coincided with an outbreak of influenza A(H5N1). Second, I examine responses to

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the 2009 influenza A(H1N1) pandemic, which took place during a liquidity crisis sparked by the bursting of the US housing market bubble, to show how the epidemiology of infectious disease became more fully integrated into economic thinking, converging with complex system theory. Finally, I reflect on the implications of translating such epidemiological models into economics. While there is a substantial literature on the use of epidemiological models in evaluating the economic impact of responses to public health interventions for infectious disease,<sup>5</sup> surprisingly little has been written about the pervasive use of disease analogies by economists in relation to the dynamics of the financial system. This is a serious omission, I suggest, since infectious disease analogies may assume equivalences and correlations that do not exist.

## Epidemiology and the biological turn in economics

Analogies of economic downturns with disease and sickness have a long history. In the Renaissance, the view that illness was the result of a humoral imbalance within the body began to shift slowly and in some measure towards an understanding of infection caused by external agents (notwithstanding continuing belief in the miasmatic aetiology of disease and in the role of providence). Trade and disease became conceptually linked, since the increasingly global nature of trade presented dangers of exposure to foreign infections.<sup>6</sup> Commercial language became infused with infectious disease metaphors. In the seventeenth century, knock-on effects in the economic system were being likened to the diffusion of an ‘epidemic disease’. As global commercial crises became more persistent and disruptive, notions of ‘contagion’ (from the Latin *contagio* meaning touching or contact) were increasingly applied to describe ‘feverish’ market speculation.<sup>7</sup> The development of evolutionary biology and the advent of germ theory in the second half of the nineteenth century transformed the ways in which biological systems were understood. ‘Contagion’ was redefined and became a critical biomedical term. Epidemiological models provided a framework for elucidating the dynamics of infectious disease, with practical implications for public health prevention.

Biology was to impact upon the emerging discipline of economic science. As Alfred Marshall, perhaps the most influential economist at the turn of the century, declared, ‘the Mecca of the economist lies in economic biology’.<sup>8</sup> Evolutionary biology continued to influence a strand of heterodox economic thinking in the twentieth century.<sup>9</sup> However, in the 1990s conceptual models from public health, underpinned by epidemiology, began to shape mainstream financial thinking. An aetiological approach, which sought to identify specific

causal factors of ‘contagion’ and its routes of transmission, was widely adopted. One context for this was the global financial crisis in 1997, when a devaluation of the Thai baht set off market perturbations that spread across much of Southeast Asia, before jumping to Latin America and Russia, causing the collapse of the hedge-fund Long-Term Capital Management in the USA. The crisis coincided with an outbreak of avian influenza A(H5N1) in Hong Kong, which infected 18 people, killing 6.<sup>10</sup> Commentators drew analogies between both ‘shocks’, correlating cross-species spillovers with economic spillover effects. Suggestively, the financial crisis was referred to by researchers and the media as the ‘Asian flu’ (and the ‘Russian virus’).<sup>11</sup> As the economist Paul Krugman remarked, ‘it was as if bacteria that used to cause deadly plagues, but had long been considered conquered by modern medicine, had reemerged in a form resistant to all the standard antibiotics’.<sup>12</sup>

Aside from the rhetorical use of infectious disease metaphors, economists sought to engage more systematically with infectious disease epidemiology. To explain the transmission channels of the financial crisis in 1997 and to understand how crises in smaller, emerging market countries, such as Thailand, could produce systemic risks in the global economy, economists drew on the epidemiological literature of ‘emerging’ infections—a term that had gained currency a few years previously with the publication of the National Academy of Science’s Institute of Medicine report *Emerging Infections: Microbial Threats to Health in the United States*.<sup>13</sup> Models were extrapolated from epidemiology to provide a conceptual framework for making visible the pathways of shock between countries that appeared to have little financial or trade connections.<sup>14</sup> Commentators noted how, during crises, volatility appeared to activate a latent interdependence.<sup>15</sup> Countries that were only minimally linked to the crisis seemed to experience a turbulence far exceeding their connectedness to the ‘infected’ economy. Informed by epidemiological research, the focus turned to indicators of exposure and the relationship between exposure to ‘infection’. The goal of financial ‘contagion’ theory was ultimately the ‘elaboration of causes’ to explain ‘patterns of disease occurrence’.<sup>16</sup>

From the late 1990s, then, economics witnessed a pronounced ‘biological turn’, as economists began to instate models from epidemiology to describe the dynamics of financial ‘contagion’. The work of the British mathematical epidemiologist Roy Anderson and the theoretical physicist Robert May seemed to provide a highly relevant analytic framework for the financial system. May had become interested in epidemiology in the 1970s and later collaborated with Anderson on the transmission dynamic of human immunodeficiency virus (HIV). Particularly relevant for economists

was the research by Anderson and May on infectious disease epidemiology. The modelling of infection disease interactions with host populations had practical implications for evaluating strategies aimed at controlling or eradicating ‘contagions’.<sup>17</sup>

Epidemiological concepts such as ‘transmission coefficient’ and ‘endemic equilibrium’ percolated into financial discourse, as economists sought to identify the transmission mechanisms of crises and predict susceptibility, viewing the financial system as a correlate of the bio-system within which infections could ‘emerge’ and spread to affect human populations. Economists sought to identify the determinants of financial contagion across and within regions, making use, for example, of multinomial logistic analyses employed in epidemiological research to predict the probability and extent of infection.<sup>18</sup> As the economist Friedrich Sell observed, epidemiology and the mechanisms of biological infection seemed to offer exciting new conceptual tools for economists to translate freely into their own practice:

‘It is worthwhile learning from epidemiology basic terms and mechanisms of infection and the transmission of infectious diseases before applying these notions to problems in the field of international finance and monetary economics. This, however, is only a first step and there are a huge variety of possible “adaptations”, “translations” and so on from epidemiology to economics’.<sup>19</sup>

## Ecosystems, infectious disease and risk

By 2009, even as the influenza A(H1N1) pandemic was unfolding and becoming entangled in the ongoing financial crisis, the term ‘financial contagion’ was being widely promoted in the media. In their account of the credit crunch, economist Nouriel Roubini and historian Stephen Mihm characteristically asserted, ‘History confirms that crises are much like pandemics: they begin with the outbreak of a disease that then spreads, radiating outwards’.<sup>20</sup>

There was a discernible reorientation in approach, however, as economists engaged with an infectious disease epidemiology that had itself been influenced by complexity theory in taking population health as an adaptive system, seeking to analyse the complex interactions between variables that determine the occurrence of disease.<sup>21</sup> From the late 1990s, multi-level approaches to designing, analysing and interpreting data emphasized the integration of molecular and genetic, individual and population levels. New paradigms—notably eco-epidemiology and socio-ecologic systems perspectives—sought to understand causality in relation to dynamic processes characterized by multilevel interactions and feedbacks.<sup>22,23</sup> Many economists employed adaptive systems

models, which had been used to elucidate risk in biological ecosystems, in order to explain how dynamic financial and non-financial systems interacted. A 2010 report by economists Prasanna Gai and Sujit Kapadia, citing Anderson and May, as well as the work of other epidemiologists, drew explicitly on the literature of complex networks as they had been applied to the epidemiology of infectious disease to propose a ‘new’ analytic model for evaluating contagion in complex financial networks that had become increasingly interdependent with the development of sophisticated financial products.<sup>24</sup>

The conflation of epidemiological and financial thinking was perhaps epitomized in the paper ‘Rethinking the Financial System’ delivered as a lecture in 2009 by Andy Haldane, Executive Director of Financial Stability at the Bank of England. Haldane began by comparing two events: the outbreak of SARS in Guangdong, China, in 2002 and the Lehman Brothers’ filing for Chapter 11 bankruptcy in a New York courtroom in September 2008. Both episodes, he argued, had underlying structural congruencies, which were ‘manifestations of the behaviour under stress of a complex, adaptive network’. Complex since both networks (biological and financial) were made up of myriad interconnections; adaptive because ‘behaviour in these networks was driven by interactions between optimizing, but confused, agents’. The SARS comparison is extended to other epidemics, including HIV/AIDS, while connections are drawn between historical responses to biological infections (quarantine and flight), which determine rates of transmission, and responses to financial crises (the hoarding of liquidity and the flight from infected assets):

‘In the present financial crisis the flight is of capital, not humans. Yet the scale and contagious consequences may be no less damaging. This financial epidemic may endure in the memories long after SARS has been forgotten. But in halting the spread of future financial epidemics, it is important that the lessons from SARS and from other non-financial networks are not forgotten’.<sup>25</sup>

As Haldane concluded, ‘the spread of epidemics and the disintegration of the financial system’ shared essential network characteristics. And given these structural parallels, it was therefore possible—and indeed, in view of the crisis situation, imperative—to import lessons from epidemiology into the financial sphere in order to identify vulnerabilities and effectively manage the financial system. Strategic regulation of the markets becomes tantamount to a public health intervention.

Thus, while epidemiology offers a descriptive model, public health suggests prescriptive approaches to dealing with contagious turbulence through global surveillance and

coordinated international outbreak responses. Haldane cites the creation in 2000 by the World Health Organization of the Global Outbreak Alert and Response Network (GOARN) as providing a model that might be replicated in the financial system in order to pool resources with a view to monitoring, identifying and managing comparable ‘outbreaks’.

This ecological approach seeks to understand how multiple factors interact on multiple levels to determine the transmission and virulence of ‘contagion’. Some economists are employing stochastic dynamic models to estimate the probability distributions of potential outcomes. Susceptible-infected-recovered transmission models, which take account of elements of uncertainty, are being used as a basis for modelling ‘the process associated with the propagation of the [financial] crisis’.<sup>26</sup>

In particular, May has promoted an ecological approach in relation to the banking system in a number of widely cited articles. In ecosystems characterized by complex interactions, the links connecting species can ‘tip’ the system into instability, rather than providing a stabilizing capacity.<sup>27</sup> A paper co-authored by Haldane and May in *Nature*, in 2011, argues that even in the aftermath of the 2007/08 financial crisis, economists persist in assuming a natural ‘equilibrium’ and would benefit from the insights yielded by the study of dynamic biological ecosystems. The paper offers policy lessons for managing the interplay between complexity and stability in financial networks to minimize systemic risk, drawing an analogy with ‘the networks within which infectious diseases spread’.<sup>28</sup>

## Implications

The turn to epidemiology and latterly to complex bio-network theories in economics reflect an attempt to break away from a reliance on more mechanistic, mathematical frameworks, which have tended to dominate mainstream economics. In contrast, epidemiological and bio-ecological approaches, informed by complexity theory, offer novel ways of re-conceptualizing the financial system in terms of organic, multi-dimensional, interactional processes.

However, there are problems with applying epidemiological models to the financial system. Translating concepts that have precise contextual meanings into a wholly different setting from the one they originated may entail concepts losing their explanatory force in their destination domain. As Mark Woolhouse has argued, when geared to specific events, epidemiological models lack generality and are therefore difficult to ‘translate’ to different settings; individual-based models are complex, hard to parametrize and require a large amount of detailed data.<sup>29</sup>

Moreover, while they draw on epidemiology in an effort to explain and predict financial ‘contagion’, economists overlook ongoing debates within epidemiology about the efficacy of epidemiology’s predictive capacity, its reliance on generic methods and the consequence of ‘risk factor’ models for public health. A discussion in the pages of this journal in 2008, for example, ‘revisited the whole idea of causality in the public health sciences’.<sup>30</sup> Particularly in the context of non-infectious diseases, causal factors are often unclear and given the lack of a coherent explanation, public health interventions thus become problematic.<sup>31</sup>

To be sure, all disciplines borrow from different frames of reference. Epidemiology itself has adapted and developed novel qualitative and quantitative methods drawing on a wide range of expertise, including the basic sciences, mathematics and the social sciences. Fields may be created and transformed precisely through cross-disciplinary fertilizations and the importation of new fundamentals from outside. Indeed, it might be argued that the adoption of epidemiological tools and methodologies in economics to understand and explain causation and risk in the financial system has reinvigorated the discipline of economics, giving it new purpose.

So what are the lessons, here, for epidemiology, particularly at a time when many are debating the relationship between theory and practice in the discipline? For one, there may be a danger that the uncritical use of epidemiological concepts and methods in economics influences epidemiology itself. In their espousal of epidemiological methodologies, economists have been largely oblivious to discussions about the merits of risk-factor based analysis, causal inference, understanding and explanation. As a consequence, critical debate may be blunted within epidemiology precisely when, as Nancy Krieger has recently remarked, there is an urgency in examining the assumptions of epidemiological theory.<sup>32</sup> Secondly an epidemiological discourse, mediated through economics, has filtered into the public sphere where there is extensive and—again, predominantly accepting—media coverage of ‘contagion’. This popularizing of epidemiological terminology may dilute the potential for epidemiologists themselves to shape the terms of the debate and to explain the strengths and limitations of their approaches.

Yet notwithstanding these dangers, the engagement with epidemiological concepts and methods outside the conventional confines of the discipline also represents an opportunity. As economists grapple with epidemiological models to elucidate the complexity of the financial system, epidemiologists themselves, faced with old and new challenges to human health, may be encouraged to re-examine the assumptions that underpin their practice and knowledge, in the process re-articulating and strengthening the theoretical foundations of their discipline.

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